

*THE DETERMINATION OF THE WORK DONE UPON THE CORES OF IRON IN ELECTRICAL APPARATUS SUBJECT TO ALTERNATING CURRENTS.*¹

WHEN the case is one of a transformer, the problem may be solved by the employment of three dynamometers in the way I have already pointed out; but in that of an electro-magnet, where we have only one coil to deal with, the problem still admits of solution if we further employ a condenser of determined capacity, and possess a knowledge of the period by means of some speed indicator. The plan is as follows:—

Arrangement.—Having the machine and magnet in series, insert the three dynamometers in series immediately at one terminal of the electro-magnet, placing one pole of the condenser to the other terminal, and the second pole to that point of the middle dynamometer where its two coils join.

Observations.—Obtain good simultaneous readings of the three dynamometers, and if necessary of the speed indicator.

Elements of Calculation.—Let $\alpha_1, \alpha_2, \alpha_3$ be the angles read upon the instrument (1) in the generating section, (2) in the electro-magnet section, (3) which has its coils divided.

Let the reducing formula for the three instruments be respectively,

$$\begin{aligned} (\text{Current})^2 &= k_1 \theta, \\ &= k_2 \theta, \\ &= k_3 \theta. \end{aligned}$$

Let C be the capacity of the condenser.

R „ „ resistance of the electro-magnet.

T „ „ semi-period.

Then the entire power at work beyond the terminals, *i.e.* the heating of the wire, the heating of the core by induced currents, and the heating of the core due to hysteresis is expressed by the simple formula—

$$\frac{T}{\pi C} \sqrt{k_1 k_2 \alpha_1 \alpha_2 - k_3^2 \alpha_3^2}.$$

The expression itself is independent of the resistance, but if we desire to know the power heating the core, we must deduct from the above the power heating the wire, *viz.* :

$$k_2 \alpha_2 R.$$

The difference between these two quantities also happens to be proportional to the tangent of the magnetic lag, another proof of the universal concurrency of lag and loss of power.

Royal Naval College, Greenwich, October.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Dr. A. Macalister has been elected Chairman of Examiners for the Natural Sciences Tripos. Dr. C. H. Ralfe has been appointed an additional examiner in Medicine. Prof. Hughes has been elected a member of the General Board of Studies, Mr. J. Prior and Mr. C. Geldard members of the Botanic Garden Syndicate, Dr. Cayley a member of the Library Syndicate, Prof. I. J. Thomson and Mr. H. F. Newall members of the Observatory Syndicate, Dr. Bradbury and Dr. Ingle members of the State Medicine Syndicate, Mr. L. Humphry a member of the Special Board for Medicine, Mr. W. N. Shaw of the Fire Prevention Syndicate, Dr. Besant of the Mathematical Board, Mr. Newall of the Physics and Chemistry Board, and Dr. Gaskell of the Biology Board. Mr. E. H. Griffiths, Lecturer at Sidney, has been approved as a Teacher of Physics with reference to the regulations for medical degrees.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, November 20.—“On the Specific Heats of Gases at Constant Volume. Part I. Air, Carbon Dioxide, and Hydrogen.” By J. Joly, M.A., B.E., Assistant to the Professor of Civil Engineering, Trinity College, Dublin. Communicated by Prof. Fitzgerald, M.A., F.R.S., F.T.C.D.

¹ By T. H. Blakesley, M.A., M.Inst.C.E., Hon. Secretary of the Physical Society.

In this first notice the specific heats, at constant volumes, of air, carbon dioxide, and hydrogen are treated over pressures ranging from 7 to 25 atmospheres. The range of temperature is not sensibly varied. It is found that the specific heats of these gases are not constant, but are variable with the density. In the case of air the departure from constancy is small and positive; that is, the specific heat increases with increase of the density. The experiments afford directly the mean value 0.1721 for the specific heat of air at the absolute density of 0.0205, corresponding to the pressure of 19.51 atmospheres. A formula based on the variation of the specific heat with density observed in the experiments ascribes the value 0.1715 for the specific heat at the pressure of one atmosphere. The formula assumes the specific heat to be a linear function of the density, which must as yet be regarded only as an approximation, the exact nature of the relation being concealed by variations among the experiments.

These results appear to be in harmony with the experiments of Wiedemann on the specific heat at constant pressure, and of Rowland on the mechanical equivalent of heat, from which the value 0.1712 is deduced for C_v at 760 mm.

The experiments on carbon dioxide reveal a more rapid variation of the specific heat with density, the variation in this case being again positive in sign. The formula

$$C_v = \rho \times 0.2064 + 0.16577$$

appears with considerable reliability to express the relation between specific heat and density.

The relation between specific heat and density in the case of hydrogen is of a negative character; that is, the specific heat diminishes with increase of density. The experiments are chiefly directed to elucidate this point, for, owing to the difficulty of preparing pure hydrogen, it was found that variations in the quantitative results of experiments on different samples of the gas were unavoidable. Accordingly the experiments were directed to a comparison of the specific heats of like samples of the gas at different densities. The variation with density is small, but (with one exception) all experiments on the purer hydrogen ascribe a negative character to it.

The nature of these variations of specific heat with change of density is, in the case of the three gases, in accord with their behaviour as regards Boyle's law, within the range of pressure.

The experiments were effected in the steam calorimeter, a differential method being used in which an empty or idle vessel is thermally compared with the vessel holding the gas at high pressure. The vessels possessing approximately the same calorific capacity, the result, theoretically, is as if the gas was dealt with isolated from any containing vessel. Although practically this is not attained, many sources of error are eliminated by the procedure adopted.

November 27.—“On the Homology between Genital Ducts and Nephridia in the Oligochaeta.” By Frank E. Beddard, M.A., Prosector of the Zoological Society. Communicated by Prof. E. Ray Lankester, M.A., LL.D., F.R.S.

It is usually stated in text-books that the genital ducts of the Oligochaeta are homologous with nephridia; but nevertheless the question is one which has not yet been satisfactorily settled, for the total independence of the two structures in *Lumbricus* and those aquatic Oligochaeta of which the development is known is a difficulty in the way of accepting this view. Claparède, who first clearly formulated the arguments in favour of regarding the genital ducts as slightly modified nephridia, made a mistake in stating that the genital segments of the aquatic Oligochaeta contain no nephridia; this error was pointed out by Vejdovsky, who discovered that the genital segments are originally furnished with nephridia, which atrophy on the ripening of the sexual products and the appearance of their ducts. Prof. Lankester pointed out that in *Lumbricus* the genital ducts and the nephridia have a close relation to one or other of the two pairs of setæ with which each segment is provided. He suggested that the genital ducts might represent the only portion left of a ventrally opening series of nephridia. M. Perrier's memorable investigations into the structure of exotic earthworms tended at first to confirm this theory. He discovered that in one earthworm (*Plutellus*) the nephridia alternated in position from segment to segment, thus suggesting that the supposed original two sets of nephridia had both partly persisted and partly disappeared. In other forms the nephridia were found to be related to the ventral setæ, and the genital apertures to

the dorsal setæ, the exact converse of the condition which occurs in *Lumbricus*. Later investigations, however, which resulted in the discovery that the genital apertures and nephridiopores may coincide at the same setæ, led M. Perrier to abandon the hypothesis. My own discovery, first published in the Proceedings of this Society, that in *Acanthodrilus multiporus* there are more than a single pair of nephridiopores to each segment, removed the difficulties urged by Perrier. And as this discovery has been extended by myself and by others to many species and genera of earthworms, there can be no longer any intrinsic improbability in the hypothesis. The whole subject has been lately reviewed by Eisig in his treatise upon the anatomy and physiology of the Capitellidæ, which forms one of the series of monographs issued by the Zoological Station at Naples. Dr. Eisig decides that the genital ducts are probably modified nephridia in the Oligochaeta; in the Capitellidæ they certainly are; but, as the Capitellidæ do not appear to me to be so nearly related to the Oligochaeta as Dr. Eisig considers, I should regard this argument as only having the force that an argument from analogy can have. Since the appearance of Dr. Eisig's work, an important paper by Dr. Stolc, dealing with the generative organs of *Eolosoma*, has come into my hands; it appears that in this Annelid there are no special sperm ducts, but that the function of such ducts is performed by several pairs of nephridia. This fact, however, interesting though it is, is not a proof of the homology between sperm ducts and nephridia in other types.

I have lately had the opportunity of studying the development of the New Zealand species *Acanthodrilus multiporus*. The sum of money which the Government Grant Committee of the Royal Society were good enough to place at my disposal has enabled me to defray the expenses of this investigation.

In the young embryos of this worm each segment is furnished with a pair of nephridia, each opening by a ciliated funnel into the segment in front of that which carries the dorsally placed external pore. In later stages the funnels degenerate, and that portion of the tube which immediately follows the funnel becomes solid, losing its lumen; at the same time the nephridium branches, and communicates with the exterior by numerous pores. At a comparatively early stage, four pairs of gonads are developed in segments X.-XIII.; each of these is situated on the posterior wall of its segment, as in *Acanthodrilus annectens*, and not on the anterior wall, as in the majority of earthworms. When the gonads first appear, the nephridial funnels, with which they are in close contact, are still ciliated, and their lumen is prolonged into the nephridium for a short distance. Later the cilia are lost, and the funnels increase greatly in size, while those of neighbouring segments—in fact, all the remaining funnels—remain stationary for a time, and then become more and more degenerate. The large funnels of the genital segments become the funnels of the vasa differentia and oviducts; it will be observed that the number of ovaries and oviducal funnels (two pairs) at first corresponds to that of the testes and sperm duct funnels; subsequently the gonads and commencing oviducts of segment XII. atrophy. Each of these large funnels is continued into a solid rod which passes back through the septum, and then becomes continuous with a coiled tuft of tubules, in which there is an evident lumen, and which is a part of the nephridium of its segment. In the segments in front of and behind the genital segments, the rudimentary funnels communicate in the same way with a solid rod of cells which runs straight for a short distance and then becomes coiled and twisted upon itself and provided with a distinct lumen. In fact, apart from the relative size of the funnels and the presence of the gonads, it would be impossible to state from which segment a given section through the terminal portion of a nephridium had been taken. In a later stage the large funnels of the genital segments become ciliated; but this ciliation takes place before there is any marked change in the tube which is connected with the funnel.

In the young worm which has just escaped from the cocoon the funnels are ciliated, and they are each of them connected by a short tube, in which a lumen has been developed, but which ends blindly in close proximity to a coil of nephridia. No trace of any nephridial tube other than the sperm duct or oviduct could be observed, whereas in the preceding and succeeding segments the rudimentary nephridial funnel, and a straight tube leading from it direct to the body wall, was perfectly plain. Dr. Bergh has figured, in his account of the development of the generative organs of *Lumbricus*, a nephridial funnel in close con-

tact with the funnel of the genital duct. It may be suggested that a corresponding funnel has been overlooked in the embryo *Acanthodrilus*; the continuity of a structure, identical (at first) with the nephridia of the segments in front and behind, with the genital funnels, seems to show that a search for a small nephridial funnel would be fruitless.

I can only explain these facts by the supposition that in *Acanthodrilus multiporus* the genital funnels and a portion at least of the ducts are formed out of nephridia. This mode of development is a confirmation, to me unexpected, of Balfour's suggestion that in the Oligochaeta the nephridium is broken up into a genital and an excretory portion.

In the comparison of the facts, briefly described here, with the apparently independent origin of the generative ducts in other Oligochaeta, it must be borne in mind that in *Acanthodrilus* the segregation of the nephridium into several almost detached tracts communicating with the exterior by their own ducts precedes the formation of the genital ducts.

"The Patterns in Thumb and Finger Marks: on their Arrangement into naturally distinct Classes, the Permanence of the Papillary Ridges that make them, and the Resemblance of their Classes to ordinary Genera." By Francis Galton, F.R.S.

The memoir describes the results of a recent inquiry into the patterns formed by the papillary ridges upon the bulbs of the thumbs and fingers of different persons. The points especially dwelt upon in it are the natural classification of the patterns, their permanence throughout life, and the apt confirmation they afford of the opinion that the genera of plants and animals may be isolated from one another otherwise than through the influence of natural selection.

The origin of the patterns was shown to be due to the existence of the nail, which interfered with the horizontal course of the papillary ridges, and caused those near the tip to run in arches, leaving an interspace between them and the horizontal ridges below. This interspace was filled with various scrolls which formed the patterns. The points or point at which the ridges diverged to inclose the interspace were cardinal points in the classification. It was shown that there were in all only nine possible ways in which the main features of the inclosure of the interspace could be effected. In addition to the nine classes there was a primary form, occurring in about 3 per cent. of all the cases, in which the interspace was not clearly marked, and from this primary form all the other patterns were evolved. The forms of the patterns were easily traced in individual cases by following the two pair of divergent ridges, or the one pair if there was only one pair, to their terminations, pursuing the innermost branch whenever the ridge bifurcated, and continuing in an adjacent ridge whenever the one that was being followed happened to come to an end. Twenty-five of the principal patterns were submitted, and a few varieties of some of them, making a total of forty. They are by no means equally frequent.

The data as to the permanence of the patterns and of the ridges that compose them were supplied to the author by Sir W. J. Herschel, who, when in the Indian Civil Service, introduced in his district the practice of impressing finger marks as a check against personation. Impressions made by one or two fingers of four adults about thirty years ago, and of a boy nine years ago, are compared with their present impressions. There are eight pairs of impressions altogether, and it is shown that out of a total of 296 definite points of comparison which they afford, namely the places where ridges cease, not one failed to exist in both impressions of the same set. In making this comparison no regard was paid to the manner in which the several ridges appear to come to an end, whether abruptly or by junction with another ridge. The reason was partly because the neck where junction takes place is often low, and may fail to leave a mark in one of the impressions.

Lastly, the various patterns were shown to be central typical forms from which individual varieties departed to various degrees with a diminishing frequency in each more distant degree, whose rate was in fair accordance with the theoretical law of frequency of error. Consequently, wide departures were extremely rare, and the several patterns corresponded to the centres of isolated groups, whose isolation was not absolutely complete, nor was it due to any rounding off by defined boundaries, but to the great rarity of transitional cases. This condition was brought about by internal causes only, without the least help from natural

selection, whether sexual or other. The distribution of individual varieties of the same patterns about their respective typical centres was precisely analogous in its form, say, to that of the shrimps about theirs, as described in a recent memoir by Mr. Weldon (Roy. Soc. Proc., No. 291, p. 445). It was argued from this, that natural selection has no monopoly of influence either in creating genera or in maintaining their purity.

"The Conditions of Chemical Change between Nitric Acid and certain Metals." By V. H. Veley, M.A.

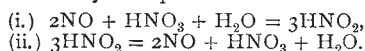
This paper is in continuation of a preliminary communication on the same subject. The main points contained in it are as follows:—

(1) The metals copper, mercury, and bismuth do not dissolve in nitric acid of about 30 per cent. concentration (the acid commonly employed for the preparation of nitric oxide gas) and heated to a temperature of 30° C., provided that nitrous acid is neither present initially nor formed subsequently. To prevent this, it is necessary in the cases of copper and bismuth to add a small quantity of some oxidizing substance, such as hydrogen peroxide or potassium chlorate, or, as less efficacious, potassium permanganate, or to pass a current of air, or, lastly, such a substance as urea, which destroys the nitrous acid by its interaction.

(2) If the conditions are such that these metals dissolve, then the amount of metal dissolved and the amount of nitrous acid present are concomitant variables, provided that the nitric acid is in considerable excess. Change of conditions, such as concentration of acid and variation of temperature, which increase the former increase also the latter.

(3) If the conditions are such that these metals dissolve, it would appear that the metallic nitrite is at first formed, together with nitric oxide; the former is decomposed by the excess of nitric acid to liberate nitrous acid, while the latter reduces the nitric acid to form a further quantity of nitrous acid.

Eventually the net result is the product of two reverse chemical changes represented by the equations:—



The nitrous acid is thus destroyed as fast as it is generated.

(4) If the conditions are such that metals dissolve in nitric acid, then nitrous acid is invariably the initial product of reduction.

(5) The metals copper, mercury, and bismuth dissolve very readily in a 1 per cent. solution of nitrous acid; under these conditions nitric acid present in slight excess interferes with, rather than promotes, the chemical change. This result is probably due to the greater stability of nitrous acid in the presence of nitric acid.

(6) Hydrogen gas reduces nitric to nitrous acid in presence of cupric or lead nitrate; it also converts mercuric into mercurous nitrate, but does not produce any change in solutions of bismuth and zinc nitrates dissolved in nitric acid.

Physical Society, November 14.—Prof. W. E. Ayrton, F.R.S., President, in the chair.—The following communications were made:—On certain relations existing among the refractive indices of the chemical elements, by the Rev. T. Pelham Dale. The first part of the paper corroborates the results announced in a communication made in May 1889 on the same subject, and says that as far as experimental data are forthcoming the refraction $(\mu - 1)$ divided by the vapour density (d) is equal to a constant multiplied by some integer. Several metals whose refractions have since been determined conform to this law. On examining the relation between molecular weight (M) and refraction, similar conclusions are arrived at; for to a fair degree of approximation the ratio $M/(\mu - 1)$ is a constant, or a simple multiple of this constant. The question as to how far the relation $(\mu - 1)/d = c$ holds good for the same element in the three states of vapour, liquid, and solid, has been examined as far as data exist for this purpose. The resulting numbers are not identical, but some of the data themselves are doubtful. Another relation is between the molecular distances (h) (see Proc. Phys. Soc., vol. ix. p. 167) and the atomic weight (a) of the elements, h being nearly proportional to $\sqrt{a}$. In the case of selenium, sulphur, and phosphorus, the agreement is close, but for bromine, chlorine, and carbon, not so good. A fifth relation appears to exist between the upper limit of refraction and the line spectra of elements. For example, the upper limit of refraction for selenium occurs at wave-length 5295.7, whilst

its spectrum exhibits a remarkable series of strong lines about this wave-length. A similar relation apparently holds with sulphur, phosphorus, and bromine. Gold also shows a series of strong lines about c , in the vicinity of which the metal has the greatest reflective power. The author finds that selenium polarizes and reflects nearly all the light that falls on it at a large angle, and suggests that it may be used in polariscopes. He has also endeavoured to connect together the phenomena of a limit of refraction and anomalous dispersion. In the case of fuchsin the dark space coincides with the limit of refraction, and the same is probably true of cyanin. If one of the anomalous indices be given the other can be found. He also believes that bodies of high molecular weight give anomalous dispersion, and thinks solutions of iodine will exhibit the phenomenon. The mathematical investigation of the whole subject involved difficulties arising from the want of trustworthy data, and the author hopes that some member will take up the necessary experimental determinations. Dr. Gladstone thought the author under-estimated the amount of work done and in progress on the subject, for the question whether $(\mu - 1)/d$ is constant or not is being investigated by many. The French physicists, he said, had found the quantity nearly constant, but Lorenz's expression $(\mu^2 - 1)/(\mu^2 + 2)$ is slightly better when applied to compounds in the liquid and gaseous states. Metals were difficult to deal with, especially as, according to the recent paper of Du Bois and Reubens, their refractions do not follow the law of sines. Mr. Dale here suggested that they might be related to hyperbolic sines. Dr. Gladstone, continuing, said that, by taking solutions of metals, it was found that their specific refractive energies were nearly inversely as the square roots of their combining weights, but at present the known cases were not sufficient to establish a law. Prof. Rüchler said that of the two expressions, $(\mu - 1)/d$ and $(\mu^2 - 1)/(\mu^2 + 2)$, the latter seemed preferable, for it could be converted into electrical quantities by writing K for μ^2 . The expression then becomes $(K - 1)/(K + 2)$, and if this can be shown to be constant by electrical work, this would be an argument in its favour. On the subject of anomalous dispersion he directed Mr. Dale's attention to Mr. Glazebrook's Report on Optical Theory made to the British Association. Mr. Dale, in reply, pointed out that, from the nature of the two formulæ, any inaccuracy or variation in μ would affect theirs more than Lorenz's. He also thought that $(\mu - 1)/d$ was a limit towards which the numbers tend.—Tables of spherical harmonics, with examples of their practical use, by Prof. J. Perry, F.R.S. The author defined a spherical harmonic as a homogeneous function of x, y, z , satisfying the equation—

$$\frac{d^2V}{dx^2} + \frac{d^2V}{dy^2} + \frac{d^2V}{dz^2} = 0,$$

stated the fundamental properties of such functions, and pointed out their importance in problems on heat, electricity, and hydrodynamics. Referring to zonal harmonics (homogeneous functions of $(x^2 + y^2)^{\frac{1}{2}}$ and z), he showed that these harmonics are symmetrical with respect to the axis of z , and might be expressed as functions of the angle (θ) which the line joining the point (x, y, z) to the origin makes with the axis of z , multiplied by r^i ; where r is the radius-vector and i the degree of the homogeneous function. These functions of θ are called zonal surface harmonics, and are designated by $P_0, P_1, P_2, \dots, P_i$, according to the degree of the function, and it was the values of these quantities which form the tables brought before the Society. The tables comprise the values of P_1 to P_8 , and are calculated to 4 places of decimals and for every 1° between 0° and 90°. As an example of the use of such tables, the case of a spherical surface covered with attracting matter whose density varied as the square of its distance from a diametral plane was taken. It was required to find the potential both outside and inside the sphere, and to determine the equipotential surfaces and lines of force. The potentials inside (A) and outside (B) were shown to be given by

$$\frac{A}{\pi} = 8 + \frac{16}{5} r^2 P_2 \quad \text{and} \quad \frac{B}{\pi} = \frac{8}{r} + \frac{16}{5} \frac{1}{r^3} P_2$$

respectively. By giving A and B definite values, and choosing values of r , the corresponding P_2 's can be calculated, and the value of θ determined from the tables. Hence any equipotential surface can be easily determined, and lines drawn to cut these surfaces orthogonally are lines of force. Another problem which had been tried consisted in finding the directions of the lines of force near a circular coil of rectangular cross-section when an electric current circulates in the coil. This was treated

approximately by first calculating the potential at 6 points along the axis in the neighbourhood of the coil, and then finding by Gauss's method the coefficients $A_0, A_1, A_2, \&c.$, of an expression in ascending powers of z which agreed with the calculated potentials at the points chosen. The formula

$$V = A_0 + A_1 r P_1 + A_2 r^2 P_2 + \&c.,$$

or its corresponding expression in inverse powers of r , was then assumed to give the potential at any point in the space considered. By giving V definite values, a series of equipotential surfaces were determined, and the lines of force drawn. On putting the calculations to the test of experiment, the approximate solution of this very difficult problem was found to be very nearly correct.

Linnean Society, November 20.—Prof. Stewart, President, in the chair.—Mr. G. Murray exhibited specimens of a fresh-water *Delesseria* previously unknown.—On behalf of Mr. Henry Hutton, of Cape Town, Mr. B. D. Jackson exhibited some follicles and seeds of a somewhat rare *Asclepiad* (*Dregia floribunda*); and showed also, on behalf of Mr. W. Matchwick, some ripened seeds of *Ailanthus glandulosa* from a tree at Reigate said to be a hundred years old.—Prof. Bower exhibited several drawings from microscopic sections of Carboniferous nodules belonging to Prof. Williamson, and pointed out the peculiarities of structure. Microscopic details of such sporangia being very rare, he remarked that a comparison of the slides showed a peculiar uniformity of type. For comparison with these sporangia from the coal, he exhibited sections of the sporangia of *Todea barbara*, and while not going so far as to refer these Carboniferous sporangia (which are not attached to the plants which bore them) to any distinct genus, he thought the Osmundaceae affinity was unmistakable.—Mr. J. E. Harting exhibited some original MSS. and water-colour sketches of birds, fishes, and plants, found in Sussex by William Markwick, the friend and correspondent of Gilbert White, of Selborne, which had been presented by him to the Society in his lifetime, and had been lost sight of for many years. The drawings are sufficiently well executed to enable the correct determination of several species which the author had failed to identify.—A paper was read by Prof. T. Johnson, of Dublin, on *Punctaria*, a genus of brown seaweeds (*Phaeophyceae*). He described in detail the formation of the plantlets by trichothallic germination from the tufts of primary hairs and from the secondary hairs formed on epicortical filaments on the old thallus of *P. plantaginea* and *P. latifolia*. He pointed out that neither the nature of the dots nor the position of the sporangia is of specific value, and that sporangiferous and plant-forming hairs are to be found on the filamentous root-disk of *P. tenuissima*, Grev., which, he maintained, is the young state of one species, of which *plantaginea* and *latifolia* are the more mature growths.—Mr. Vaughan Jennings gave an abstract of a paper on a variety of sponge, *Alectona millari*, Carter, boring in the shell of *Lima excavata*, from the Norwegian coast. The sponge had endeavoured to grow inwards, dissolving the nacreous layer and encroaching on the mollusk, instead of restricting its wanderings to the thickness of the shell. The mollusk had retaliated by depositing fresh layers on the intruder, and the struggle had gone on until the chambers were several times the normal thickness of the shell, and were roofed over by a thin curved layer of secondary shell substance, while the points at which branches had been pushed further in were represented by thick conical papillæ.

CAMBRIDGE.

Philosophical Society, November 10.—Prof. Darwin, President, in the chair.—The following communications were made:—Note on the principle upon which Fahrenheit constructed his thermometrical scale, by Arthur Gamgee, F.R.S., Emeritus Professor of Physiology in the Owens College (Victoria University). The author commenced by drawing attention to the fact that, although the Fahrenheit thermometer has been so generally used in England, no accurate information was to be found in our text-books concerning the principles upon which its scale had originally been constructed. He referred, however, to a view advanced by Prof. P. G. Tait in his elementary treatise on "Heat," and which had been accepted by many teachers, according to which Fahrenheit divided his scale between 32° and 212° into 180 degrees, in imitation of the division of a semicircle into 180 degrees of arc. This theory rested on the incorrect supposition that, before Fahrenheit's time, Newton had suggested, as a basis for a thermometric scale, the fixing of the freezing and boiling points of

water, the space between these being divided into a number of equal degrees. The author pointed out that in his "Scala graduum caloris," Newton made no such suggestion as that attributed to him by Prof. Tait, and prior to him by Prof. Clerk Maxwell; and, indeed, that Fahrenheit had settled the basis of his scale and had constructed a large number of thermometers, which were used by scientific men throughout Europe, many years before the discovery by Amanton (which Fahrenheit confirmed and gave precision to) of the fact that under a constant pressure the boiling point of water is constant. The author stated that the thermometers which were first constructed by Fahrenheit were sealed alcoholic thermometers, provided with a scale in which two points had been fixed. The zero of the scale, representing the lowest attainable temperature, was found by plunging the bulb of the thermometer in a mixture of ice and salt, whilst the higher of the two points was fixed by placing the thermometers under the armpit or inside the mouth of a healthy man. The interval between these two points was, in the first instance, divided into 24 divisions, each of which corresponded to supposed well-characterized differences in temperature, and each being subdivided into four. In his later alcoholic and mercurial thermometers, the 24 principal divisions were suppressed in favour of a scale in which 96 degrees intervened between zero and the temperature of man; in these later thermometers the 32nd degree was fixed by plunging the bulb of the thermometer in melting ice. The author then pointed out that Fahrenheit was led to construct mercurial thermometers in order to be able to ascertain the boiling point of water; with this object the scale, constructed as has been stated, was continued upwards, in some cases so as to include 600 degrees. It was as the result of experiment alone, that the number 212 was obtained as the temperature at which water boils, at the mean, atmospheric pressure. The author in conclusion argued that Fahrenheit took as the basis of his thermometric scale the duodecimal scale, which he was constantly in the habit of employing.—On variations in the floral symmetry of certain plants with irregular corollas, by Mr. W. Bateson and Miss A. Bateson.—On the nature of the relation between the size of certain animals and the size and number of their sense-organs, by H. H. Brindley. In speculation as to the evolution of various forms, it is generally held as a principle that the conditions of the struggle for existence are such that variations in the direction of atrophy or diminution in bulk of a useless organ must necessarily be beneficial by reason of the saving of tissue and effort which is effected by this reduction. It has been assumed by many that this benefit must be so marked as to lead to the natural selection of the individuals thus varying. This principle has been invoked especially in the case of sense-organs, and, for example, it has been suggested that the blindness of cave-fauna may have come about by its operation. With the object of testing the truth of this assumption, it seemed desirable to obtain a knowledge of the normal variations in size and number of sense-organs occurring within the limits of a single species. The cases chosen were (1) the olfactory organ of fishes (eel, loach, *Pleuronectidae*, &c.), and (2) the eyes of *Pecten opercularis*. In the first case tables were given showing that large individual fluctuations occur, but that on the whole the number of olfactory plates increases with the size of the body; and it was pointed out that a similar relation holds with regard to the eyes of fishes. In the case of *Pecten*, however, though the size of the eyes increases with the diameter of the animal, yet in specimens having a diameter of 3 cm. to 6 cm. the number of the eyes is not thus related (cp. Patten), but varies in a most surprising and, as it were, uncontrolled manner. Statistics were given showing that, in individuals of the same size, the number of eyes may vary between 70 and 100, and that no uniformity is to be found. It was pointed out that these eyes are large and complicated organs, having lens, retina, tapetum, &c., involving great cost in their production. These facts suggest that the "economy of growth" cannot be a principle of such precise and rigid character as to warrant its employment as a basis for speculation as to the mode of evolution of a species. The diverse results in the case of the two sets of organs examined further indicate that the problem is one of far greater complexity, and shows clearly that argument from analogy is inadmissible in these cases.—On the oviposition of *Agelena labyrinthica*, by C. Warburton. The oviposition and cocooning of *Agelena labyrinthica* is a striking case of the performance of a series of complicated operations in obedience to a blind instinct. The eggs are always laid at night, but the presence of artificial light is

quite disregarded by the animal. For about 24 hours before laying, the spider is engaged in preparing a chamber for the purpose. Near its roof a small sheet is then formed, and the eggs are laid upwards against it and are covered with silk. A box is then constructed with this sheet as its roof, and is firmly attached by its angles to the roof and floor of the chamber. This box is constructed and jealously guarded even if the eggs are removed immediately on oviposition. The whole operation involves about 36 hours of almost incessant industry.—Supplementary list of spiders taken in the neighbourhood of Cambridge, by C. Warburton.

PARIS.

Academy of Sciences, November 24.—M. Hermite in the chair.—Experiments on the mechanical actions exerted on rocks by gas at a high pressure and in rapid motion, by M. Daubrée. The working of diamond mines in South Africa has revealed the existence of vertical canals or chimneys in the earth's crust. All these chimneys are circular or elliptical in section. Their diameter varies from 20 metres to 450 metres, and is generally comprised between 150 metres and 300 metres. Their depth is considerably greater. M. Daubrée finds that he can produce precisely similar formations by means of the gas evolved when dynamite or gun-cotton is exploded, and therefore believes that the chimneys referred to are produced by the action of gases at high pressures and velocities. That the effect may be considerable is evident from a consideration of the action of gases at high pressure upon the meteorites that traverse our atmosphere.—On some facts relative to the history of carbon, by MM. Paul and Léon Schutzenberger.—On the relation of the circumference to the diameter, by Prof. Sylvester. Lambert has shown that π cannot be the square root of a whole number. The author proves that π cannot be the root of a rational equation.—Observations of Zona's comet (November 15, 1890) made at Paris Observatory with the West Tower equatorial, by M. G. Bigourdan. Three observations for position were made on November 21.—Observation of the same comet made with the East Tower equatorial, by Mdlle. D. Klumpke. An observation for position was made on November 21.—Generalization of one of Abel's theorems, by M. Albert La Maestra.—Variations of conductivity under different electrical influences, by M. Ed. Branly. If a circuit be formed with a Daniell's cell, a high resistance galvanometer, and a very thin layer of copper deposited on a ground glass or ebonite plate, 7 cm. long and 2 cm. wide, only an insignificant current passes. An abrupt diminution of resistance is experienced, however, when one or more electric discharges, from a Wimshurst machine or a Ruhmkorff's coil, are produced in the neighbourhood of the circuit. The action diminishes as the distance of the sparking apparatus increases, but it may be very easily observed, without special precautions, at several metres. The author has examined the conditions necessary to produce the observed phenomena.—Periodic visibility of interference fringes, by M. Charles Fabry.—On the artificial production of a chromium blue, by M. Jules Garnier. By heating in a brasqued crucible a mixture of K_2CrO_4 48·62 grammes, fluor spar 65 grammes, and silica 157 grammes, the author obtained a blue glass, the colour of which he attributes to reducing action taking place at a high temperature in the chromium salt.—Researches on the application of the measure of rotatory power to the determination of combinations formed by aqueous solutions of malic acid with the double molybdate of potassium and sodium, and the acid molybdate of sodium, by M. D. Gernez.—On the employment of the potato in the agricultural distillery in France, by M. Aimé Girard. The French potato crop in 1890 was remarkable for quantity and quality. The author urges the application of these crops to the production of alcohol, and experimentally proves that such a use may be commercially successful.—On the spermatozoa of Locustides, by M. Armand Sabatier.—On *Cyclotella annelidicola* (van Beneden and Hesse), by M. Henri Prouho.—On the destruction of *Heterodera schachtii*, by M. Willot.—On an eruptive rock from Ariège, and on the transformation of felspar into wernerite, by M. A. Lacroix.—On a tornado observed at Fourchambault (Nièvre), by M. Doumet-Adanson.

GÖTTINGEN.

Royal Society of Sciences.—The *Nachrichten* from January to June 1890, contain the following papers of scientific interest:—

January.—B. Galitzine, on Dalton's law. The author reviews the different estimates taken of Dalton's law, and concludes

from his experiments that it is not accurately true either as regards the resultant pressure of a mixture of gases, or as regards the pressure of vapours.

February.—Nernst, on a new principle in the determination of molecular weights. The author gives the results of experiments conducted to verify the familiar formula $a - a'/a' = n/100$.

March.—Felix Klein, on the theory of Lamé's functions. This is an account of lectures in continuation of previous courses, and is concerned with the extension of Lamé's equation, the replacing of his functions by algebraic forms, and the conformable representation of a quotient of two solutions. Hertz, on the fundamental equations of electrodynamics. This is an attempt to explain the method of proof and the significance of Maxwell's equations.

May.—Voigt, on the coincidence of two simple tones—being a reconciliation of the formulæ obtained by Helmholtz and R. König. Hartlaub, contribution to the knowledge of the *Comatulidæ* of the Indian Archipelago. Riecke, the pyroelectricity of tourmaline. The object is twofold—to examine the correctness of the formula $\epsilon = E(1 - e^{-at})$ for the electric charge during the cooling (where t denotes the time), and to find the dependence upon the difference of the initial and final temperatures of the electricity developed during the cooling.

June.—Riecke, on W. Gibbs's theory of the changes of state of a system; geometrical development of the same. Fr. Brioschi, on a transformation of the differential equation of the even sigma-function of two variables; deduction of the development. Schoenflies, the mutual relations of the various theories of crystalline structure; a general account.

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